AN ADRENERGIC COMPONENT OF THE NERVOUS APPARATUS OF THE AORTIC REFLEXOGENIC ZONE

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The structural organization of the adrenergic (sympathetic) component of the autonomic innervation of the depressor zone of the cat aortic arch was studied by luminescence microscopy of the catecholamines. A terminal adrenergic plexus, branching extensively in the connective-tissue basis of the depressor area of the aortic arch, was discovered. The participation of vessels supplying blood to the depressor area was established. Adrenergic neurons were found in the territory of the depressor zone of the aortic arch. It is postulated that the adrenergic component of the depressor zone of the aortic arch participates in the peripheral mechanism of the regulatory effects of the sympathetic nervous system on the baroreceptor apparatus.

KEY WORDS: aorta – nervous apparatus; adrenergic neurons; vasomotor innervation of blood vessels; catecholamines.

Numerous observations have been described in the physiological literature to show the effect of the tone of the autonomic nervous system on the functional activity of the vascular baroreceptor zones such as the aortic and carotid sinus zones [1, 6, 7, 12, 13, 16]. It is postulated that this effect is mediated through direct or indirect contacts of the autonomic nervous structures with the baroreceptor apparatus. From the morphological point of view, relations existing between these nervous structures have been inadequately studied. Only in a few papers is the presence of elements of autonomic innervations close to the vascular baroreceptors mentioned as a simple statement of fact [2, 10, 18].

The writer has reported previously [9] the existence of a powerfully developed autonomic component, characterized by a unique structural organization and by intimate topographic connections with the baroceptor structures, on the territory of the depressor zone of the aortic arch. On the basis of histochemical observations (using the thiocholine method of Koelle and Gomori to identify cholinergic nervous structures and for experimental-morphological analysis indesympathization experiments) the autonomic plexus of the depressor zone of the aortic arch contains a wide distribution of elements of sympathetic nature. However, the methods of investigation used did not allow the morphological substrate of the sympathetic innervation of this reflexogenic zone to be differentiated. To solve this problem at the present time a luminescence-microscopic method for the detection of catecholamines in peripheral nervous structures can be used (the method of Falck and Hillarp).

The sympathetic (adrenergic) component of the autonomic innervation of the depressor zone of the aortic arch was investigated with the aid of the above method.

EXPERIMENTAL METHOD

The depressor zone of the cat aortic arch was used as the test object. Normal sexually mature animals of both sexes were used. Thoracotomy was performed under pentobarbital anesthesia. The aortic

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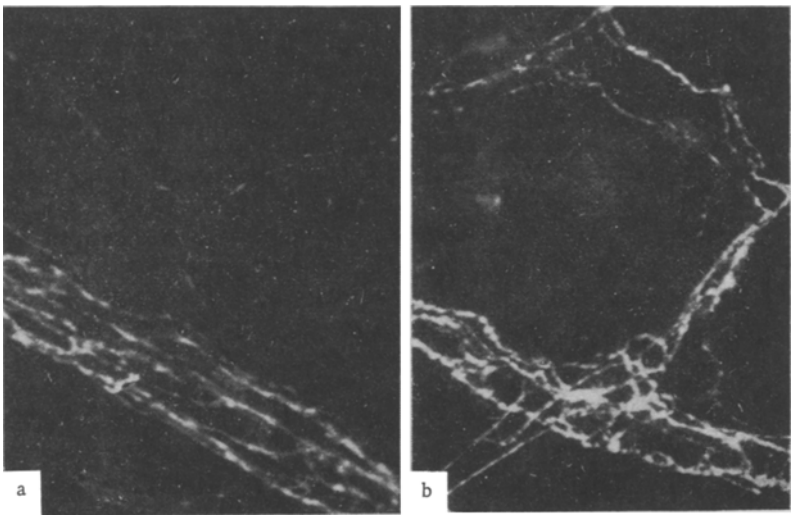

Fig. 1. Depressor zone of the aortic arch of the cat. Adrenergic nerve fibers in the composition of a nerve bundle (a) and perivascular plexus (b): intensely fluorescent varicose swellings along the course of the preterminal and terminal portions. Here and in Fig. 2, method of Falck and Hillarp, 500 ×.

arch was resected, and the area corresponding to the location of the depressor zone was immediately excised from it. The subsequent treatment of the material included all stages specified by the modified method of Falck and Hillarp [3]. The best results were obtained by the use of paraform with a relative moisture content of 47 % and with a reaction duration of 1-1.5 h (at 80°C). Sections cleared in xylol and embedded in polystyrene were examined and photographed under the ML-2 luminescence microscope.

EXPERIMENTAL RESULTS

Sections through the outer third of the aortic wall (as far as the boundary with the tunica media) were the most interesting, for it is there that the innervation of the reflexogenic zone of the aortic arch is situated. The structural basis of the depressor area consists of the adventitial connective tissue, supplied with a well-developed network of blood vessels. Besides the vessels, on the territory of the depressor area there are numerous nerves consisting of myelinated and unmyelinated fibers. On treatment of the preparations with formaldehyde vapor the nerve trunks were found to contain many axons with specific bright green fluorescence for catecholamines. These were adrenergic (sympathetic) fibers which, as thenerves divide, spread wider and wider in the tissues of the depressor area and change into preterminal and terminal portions (Fig. 1). The terminal segments have numerous strongly fluorescent varicose swellings, in which granules of the active mediator (noradrenalin) are concentrated. Numerous adrenergic fibers accompany the blood vessels of the depressor zone and ramify close to the vessel wall to form the vasomotor innervation system (Fig. 1b).

Besides the adrenergic nerve fibers belonging to the sympathetic vascular innervation, plexiform adrenergic structures not directly connected with the vascular system of the aortic wall were constantly found in the depressor area of the aortic arch. These structures formed a widely branched network of adrenergic nerve fibers with the nodal points characteristic of the peripheral autonomic plexus and representing foci of concentration of the Schwann-cell syncytium. In the immediate vicinity of the nodal points brightly luminescent (resembling catecholamine fluorescence) cellular formations, round, oval, or irregular in shape, were commonly found. In size they varied from 30 to 50 μ. The bodies of these cells gave off thin, finely varicose, fluorescent processes which immediately entered the adrenergic plexus, where they were lost among the autonomic nervous fibers resembling them closely in the type and character of their fluorescence (Fig. 2). These morphological features suggest that the cellular structures were neurons of adrenergic (sympathetic) nature. This hypothesis is in agreement with the well known fact that adrenergic neurons are found in the composition of the intramural ganglia of the heart and other organs [4, 5, 14, 15].

On the basis of the luminescence-microscopic analysis of these preparations it was difficult to establish the character of the nerve-tissue relations of the adrenergic plexus in the depressor zone of the aortic arch. Some light on this problem could be shed only by comparing the corresponding luminescence-

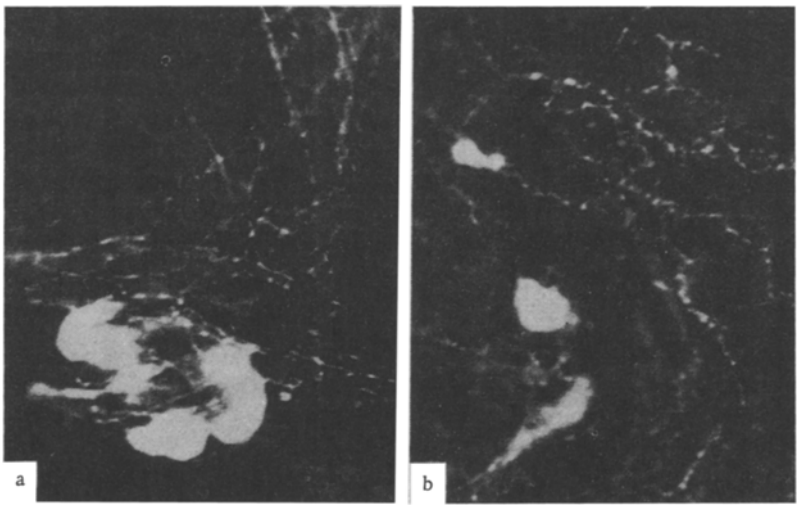

Fig. 2. Fragments (a, b) of adrenergic plexus from the depressor zone of the cat aortic arch: luminescent cellular structures can be seen (explanation in text).

microscopic data with the patterns of autonomic innervation of the depressor zone obtained by supravital staining of the nerves with methylene blue [8]. It was this method that revealed the powerful autonomic innervation of the specialized smooth-muscle cells located in the substance of the connective-tissue basis on the depressor zone of the aortic arch. By comparing this innervation system with the adrenergic plexus described above it was shown convincingly that what could be seen was a single autonomic component, as regards its architectonics and the character of its structural organization, of the depressor zone of the aortic arch. These findings suggested that the terminal component of the adrenergic plexus of the depressor zone has direct relations with the effector innervation of its smooth-muscle cells. In this connection it is worth mentioning investigations of the carotid sinus reflexogenic zone [19, 20] in which the adrenergic innervation of similar smooth-muscle cells was observed in the adventitia of the carotid sinus. The contractile function of these cells was assumed by the workers cited to be of great importance in the peripheral mechanism of sympathetic influences on the carotid sinus reflexogenic zone. This view is in full agreement with the present writer's opinion, expressed earlier, regarding the role of the specialized smooth-muscle cells of the depressor zone of the aortic arch as a factor for the autonomous control of the tone of the depressor zone and, consequently, as a functional tuning factor for the baroreceptor structures of the aortic reflexogenic zone [8].

The presence of intimate topographic relations between the adrenergic nerve structures and the baroreceptor apparatus in the depressor zone of the aortic arch suggests yet another mechanism of the sympathetic influences on the activity of the aortic baroreceptors. By this is meant the direct action of the noradrenalin secreted by functionally active synaptic structures of the adrenergic component on the aortic baroreceptors and the change in the thresholds of stimulation (sensitivity) of these baroreceptors, connected with this action of noradrenalin, with respect to the adequate stimulus, i.e., the biomechanics of the vessel wall [11, 17].

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